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Short communication

Effect of high tannin grain sorghum on gastrointestinal parasite fecal egg counts in goats

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ABSTRACT

The objective of three experiments was to determine the influence of high condensed tannin (CT) grain sorghum on gastrointestinal parasite fecal egg counts (FEC). Sixteen naturally infected Boer crossbred mixed-sex goats were used. Animals that were supplemented with grain daily were removed from pasture and placed in individual pens and fed treatment diets for 21 or 14 days (Experiment 3). Goats were allowed ad libitum access to water and diets containing high or low CT cracked grain sorghum. On day 0 and every 7 days thereafter, PCV, FEC and FAMACHA® eyelid color scores (EYE; Experiment 1 only) were recorded. For Experiment 1, percentage of animals dewormed, PCV and EYE were not influenced by treatment and averaged 13.6 ± 4.5% per treatment period, 23.4 ± 0.8% and 3.2 ± 0.12, respectively, for all animals. The FEC increased after day 0 for control but not high tannin grain sorghum fed goats (treatment by day interaction, $P < 0.02$). As expected, EYE and PCV were negatively related ($r = -0.45$; $P < 0.0005$). For Experiment 2, there was no influence of diet on PCV or FEC, but there was an effect of day on FEC ($P < 0.002$) in which all goats had higher FEC on day 0 (1956 ± 219 eggs/g) than any other sampling day. For Experiment 3, there was no effect of feeding high CT grain sorghum on FEC (2992 ± 591 eggs/g) or PCV (25.1 ± 0.5%). In these studies, high CT grain sorghum did not consistently influence FEC and did not impact PCV or number of animals requiring chemical anthelmintic treatment.

1. Introduction

The international problem with gastrointestinal nematode (GIN) parasitism in small ruminants and the development of resistance of GIN to chemical anthelmintics has been well documented in many countries, including the USA, resulting in increased research into alternatives to anthelmintics. One possible alternative is the high condensed tannin (CT) forage, sericea lespedeza (*Lespedeza cuneata*). Min et al. (2004, 2005) reported decreased fecal egg counts (FECs) and fecal egg output, as well as a reduction in larval development for Spanish wether goats and Angora does grazing sericea lespedeza. Goats fed sericea lespedeza hay also exhibited reduced adult worms and FEC when compared to those fed Bermudagrass (*Cynodon dactylon*) hay which had no CT (Shaik et al., 2006). Since the CT in sericea lespedeza is thought to be responsible for its anti-parasitic effects, and some varieties of grain sorghum

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contain CT, the objective of this study was to determine if high CT grain sorghum would influence gastrointestinal parasites in goats.

2. Materials and methods

Three separate experiments were conducted with Boer crossbred meat goats naturally infected with internal parasites. Animals were placed in individual pens with ad libitum access to fresh water and diets mixed to be isonitrogenous containing either high (HT) or low (CON; mixed varieties) CT cracked grain sorghum at 68% (Experiment 1) or 70% of the diets. All animal-related procedures were conducted in compliance with the University of Maryland Eastern Shore Institutional Animal Care and Use Committee guidelines.

In Experiment 1, 16 mixed-sex goats at 124 ± 2.9 days of age were used. The CON diet was fed to all animals for a 7-day adaptation period until day 0 when half the animals were switched to the HT diet (grain sorghum variety NK8826). Eyelid color scores using the FAMACHA® chart system (EYE) as per Kaplan et al. (2004) were also measured throughout the 21-day study period. In a second experiment, 24 mixed-sex goats at 160 ± 3.6 days of age were used. The CON diet was fed to all animals during a 28-day adaptation period (to allow for parasite infections to mature) until day 0 when half the animals were switched to the HT diet (grain sorghum variety NK8830) for 21 days. In the third experiment, 24 male goats at 259 ± 3.0 days of age were used. The CON diet was fed to all animals for a 7-day adaptation period until day 0 when half the animals were switched to the HT diet (grain sorghum variety NK180) for 14 days.

For all experiments, fecal samples were collected directly from the rectum of each animal and blood samples were collected by venipuncture at penning, day 0 and every 7 days thereafter. The Modified McMaster's technique (Whitlock, 1948) was used to measure FEC with 1 egg counted representing 25 eggs/g. Blood samples were placed directly into microhematocrit tubes to measure packed cell volume (PCV; red blood cell level, mm/serum level, mm × 100%). Animals were dewormed with a chemical anthelmintic when PCV decreased to below 20% for Experiment 1. For Experiment 2 and 3, PCV below 20% and corresponding physical signs of illness were used for treatment decisions. No animals in Experiment 2 or 3 required anthelmintic treatment.

Condensed tannin levels in the grain sorghum varieties used were measured in three samples of each variety using the modified vanillin/HCl assay (Price et al., 1978) with catechin hydrate used as the standard and results expressed as mg catechin equivalents per g of dry matter and/or using a simplied butanol–HCl assay (Terrill et al., 1992; Wolfe et al., 2008) using quebracho tannin extracts as the standard with results expressed as mg quebracho equivalents per g dry matter.

Data were analyzed using SAS (SAS Institute, 2002, Cary, NC). The variables EYE, PCV, percentage of animals dewormed (DE), and log-transformed FEC (ln (FEC + 1)) were analyzed using a mixed model analysis of variance for repeated measures data. Percentage data was also analyzed using Chi-square analysis with results similar to those for the analysis of variance. When main effects or interactions were significant ($P < 0.05$), least squares means were separated using least significant differences. Data are reported as mean ± standard error for non-transformed values.

3. Results

For Experiment 1, FEC were influenced by a treatment by day interaction ($P < 0.02$) in which FEC were higher after day 0 for goats fed control but not high tannin grain sorghum diets (Fig. 1). However, DE, PCV and EYE were not influenced by treatment (or day) and averaged 13.6 ± 4.5% (per sampling period), 23.4 ± 0.8% and 3.2 ± 0.12, respectively, for both treatments combined. As expected, EYE and PCV were negatively related ($r = -0.45$; $P < 0.0005$). Overall, 5 controls (3 on day 7; 1 each on days 14 and 21) and 4 high CT grain sorghum fed animals (2 each on days 7 and 14) were dewormed and removed from the study. For Experiment 2, there was no influence of treatment on PCV (28.8 ± 0.5%) or FEC; however, there was an effect of day ($P < 0.002$) in which all animals had higher ($P < 0.002$)

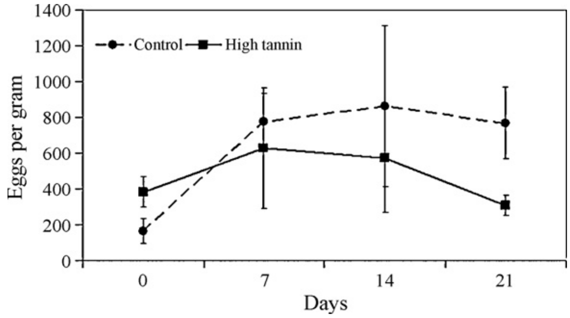

Fig. 1. Non-transformed mean (±SEM) eggs per gram of feces for goats fed high or low (control) condensed tannin grain sorghum ($n = 8$/diet) for 21 days. For the control diet, $n = 8, 5, 4, 3$ and for the treatment diet, $n = 8, 6, 4$ and 4 for days 0, 7, 14 and 21, respectively.

FEC on day 0 than any other sampling day (184 ± 384, 263 ± 60, 173 ± 38 and 544 ± 177 eggs/g for day 0, 7, 14 and 21, respectively). After day 7, for all animals, PCV tended to be higher ($P < 0.06$) than day 0 values, averaging 18.2, 17.1, 29.7 and 29.6% for days 0, 7, 14, and 21, respectively. There was no effect of feeding high CT grain sorghum on FEC (2992 ± 591 eggs/g) or PCV (25.1 ± 0.5%) for Experiment 3. The high tannin grain sorghum did contain higher CT than the control grain sorghum, but contained much less CT than sericea lespedeza hay pellets submitted for comparative purposes (Table 1).

4. Discussion

Overall, no consistent effect of high CT grain sorghum was found on measures of gastrointestinal parasite infection in the present study, with a slight suppressive effect found on FEC in Experiment 1, a decrease in FEC for both diets in Experiment 2 and no effect on FEC in Experiment 3. There was no effect on anemia level (PCV) or number needing anthelmintic treatment. The reason behind the simultaneous reduction in FEC for both treatments in Experiment 2 is not known and emphasizes the importance of maintaining untreated control animals. Self-cure and immune exclusion are known to occur in small ruminants (Miller and Horohov, 2006) and protein supplementation has been shown to reduce FEC in goats (Arsenos et al.,

Table 1
Average levels of condensed tannins in grain sorghum fed to goats to determine effects on internal parasites. Sericea lespedeza was included for comparison purposes.

Item	Condensed tannin level	
	Method 1[a]	Method 2[b]
NK8826 grain sorghum	48.3	63.7
NK8830 grain sorghum	56.3	121.0
NK180 grain sorghum	18.2	43.7
Control grain sorghum	0.4	Not available
Sericea lespedeza pellets	Not available	284.5

[a] Method 1 used the modified vanillin/HCl assay described by Price et al. (1978) with catechin hydrate used as the standard for the calibration curve and is expressed as mg catechin equivalents per g of dry matter.

[b] Method 2 used a simplied butanol–HCl assay (Terrill et al., 1992; Wolfe et al., 2008) using quebracho tannin extracts as the standard and is expressed as mg quebracho equivalents per g dry matter basis.

2009). However, animals were adapted to the protein levels in the diets prior to treatment, and an immune-mediated response is more likely for animals housed on infected pasture.

Studies with sericea lespedeza and other tannin-containing plants have indicated an impact on GIN in small ruminants. Lambs fed chicory (*Cichorium intybus*), birdsfoot trefoil (*Lotus corniculatus*) or sainfoin (*Onobrychis viciifolia*) had significant reductions of total daily *Haemonchus contortus* fecal egg output and a tendency for reduced worm burdens (Heckendorn et al., 2007) compared to those fed a ryegrass/lucerne mixture. In wether goats grazing high CT sericea lespedeza, FEC was temporarily reduced (Min et al., 2004; decreased worm fecundity) and FEC and total worm burdens were reduced in grazing does and kids when compared to control forages (Min et al., 2005). Sericea lespedeza fed as hay also resulted in lower FEC and higher PCV (after day 35) in goats than for those fed bermudagrass hay (Shaik et al., 2006; Moore et al., 2008). In addition, PCV was higher for goats fed sericea lespedeza hay (Shaik et al., 2006; Moore et al., 2008).

As with the present study, inconsistent effects on GIN have also been noted for CT-rich plants like sulla, sainfoin, birdsfoot trefoil and chicory (reviewed by Hoste et al., 2006). In addition, dried sericea lespedeza does not always lead to a reduction in FEC, even using the same batch of harvested and dried forage (Burke, unpublished data). Although the grain sorghum varieties fed in the treatment diet had higher CT concentrations than the control, all high CT varieties used had much lower CT values than sericea lespedeza. Other than concentration, the other major factor impacting the efficacy of forages or plants containing CT seems to be the structure (and bioactivity) of CT present (Hoste et al., 2006), so differences in studies could be due to forage/plant differences in these factors. In addition, parasite species may also play a role in differences among studies.

Some CT-rich plants can impact gastrointestinal nematode infections under certain conditions and therefore may eventually play a significant roll in an integrated GIN management protocol for small ruminants. However, based on the present study, feeding high CT grain sorghum to suppress GIN would not be recommended for animals with high levels of existing parasite infection.

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